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DESIGNING WITH ACTION LAYERS - A BOTTOM-UP APPROACH TO EXPLORE PRODUCT INTERACTION FOR INTUITIVE USE

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ABSTRACT
This paper presents a design teaching approach that aims to support students to shift their approach when exploring, prototyping and testing user interactions with physical products. This is conducted in a bottom-up, iterative manner to change the perspective from focusing on the opportunities of user-involvement during the form-giving process, rather than prematurely stressing the design outcome. Instead of emphasising on aesthetics and appearance, the design approach emphasises how users perceive, interact with and experience products. Through a series of workshops, a pedagogical approach was developed for exploring and designing user actions with physical products, based on the notion of 'action layers'. Action layers offer a mindset of designing, which facilitates understanding of, and design for, intuitive and tangible interaction. The approach builds on product semantics and emphasises cognitive and action-based paradigms to create intuitive and embodied information-for-use. Action layers present product interaction as a sequence of four steps; *invite*, *engage*, *enable*, and *confirm*. In the workshops, students iteratively explored form, prototyped and tested interaction with users through sketching with physical models, starting with minimal surface and edge treatments, eventually ending up with functional cues and meaningful form for a certain product type and environment. Through testing and evaluation, students learn to understand user behaviour, relate to their own expectations and intent to the design situation, and iteratively improve the design. The outcomes suggest that students advance their insights on how users interpret, respond to and interact with products, which consequently extends their ability to design products better suited for use.

Keywords: Product design, Design Elements, Product semantics, Product semiotics, Design thinking

1 INTRODUCTION AND BACKGROUND

Students of industrial or product design are expected to be proficient in designing products which fit people's expectations, motivations, and needs. Frens [1] acknowledges that form, interaction, and function are related and therefore need to be explored and designed concurrently. However, our experience is that students often take shortcuts when designing products. Rather than immersing themselves in the complexities of real and actual human-product interaction, where interaction is given by form and result in function, they often start and end with visceral, appearance-oriented design. Function, usability and interaction therefore risk being ill-considered, or even neglected, in the process of designing. Overbeeke et al. [2] argued for three types of human skills; perceptual-motor, cognitive, and emotional. While in modern digital products, cognitive skills are more emphasised [1], in physical products, all of these skills are relevant. When designing physical artefacts, information-for-use must be available which addresses these skills.
Accordingly, we see a need for a pedagogical approach, which allows them to consider interaction per se, and which provides them with a method for designing products which intuitively convey information-for-use. The approach we propose is based on the concept of action layers, which are used to model the phases of purpose-driven interaction within and around a physical product in the activity of use. The action layers are of four types as described in the following:

- The *invite* layer allows the user to understand the purpose of the product and attracts him or her for further exploration (cognitive and emotional skills). The purpose of the invite layer is to stimulate an approach behaviour, which may be driven by instrumental or social needs – users may adopt products for reasons of, e.g., utility, status or self-fulfilment.
- In the *engage* layer, the user has accepted the product and engages in examining its potential for task fulfilment (perceptual-motor and cognitive skills). The purpose of the engage layer is thus to describe the initial user interaction, i.e., to provide information-for-use.
- In the *enable* layer, the product allows the user to explore the function (perceptual-motor and cognitive skills). The purpose of this layer is to guide the user through (multiple) steps of interaction until goal-fulfilment. If appropriate information-for-use is available, the user will engage in a dialogue of exploration and discovery with the product, ideally leading to task completion.
- Finally, in the *confirm* layer, the user is given appropriate feedback of effective task completion (cognitive and emotional skills), and the product-state is returned to the invite layer.

During product use, the action layers are temporally arranged so that a user interacting with the product proceeds through the action layers, one at a time, before moving on to the next. Meaningful interaction is achieved when the user can successfully apply fitting conceptions of use on each action layer, and successfully apply all types of skill to support exploring and discovery during use.

According to the framework we propose, the task of the designer is to design cues into the product, which guide the user through each layer. These cues draw on Monö's [3] work on semantic functions, which articulate the purpose and effect of the product form in visual and functional terms. The semantic functions can be used to understand the capability of a product to inform about use and character in the eyes of the user, i.e., what the product (or parts of it) describes, explains, exhorts, and identifies. In each action layer, a particular set of semantic functions (one, several or all) needs to be in place (i.e., provide information-for-use) in order to support the user to achieve the desired interaction. We subscribe in this work to the idea that the user and product are equal counterparts in achieving successful interaction. Operatively, thus, the work of the designer is to support product use by providing necessary and suitable cues suggesting action possibilities [4], while recognising that the user must be equipped with the capability necessary to act upon those cues. As such, we recognise that interaction is mutually dependent on "knowledge in the world" as well as in "knowledge in the head", as suggested by Norman [5]. In the following, we present our pedagogical approach to designing with action layers, which is then described and illustrated through examples of student work from design workshops.

2 WORKSHOP APPROACH

During a three-day workshop conducted in the fall of 2017, industrial design engineering students at Luleå University of Technology were assigned to work in teams of two with the task of designing a product concept for a dispenser. We chose a dispenser as it is a product which often involves a complex sequence of use actions and offers a great variety in terms of purpose and placement. The students were free to choose the matter of dispensing, i.e. liquid, granulated, solid, etc., as well as environment of use, e.g., home, public, or professional. The workshop was conducted through a sequence of steps, working iteratively and bottom-up from basic form to complex product interaction. These steps are described in the following.

Step 1. Invite and engage: Intent and minimal treatments

In step 1, students explored design intent by focussing on the first two action layers of invite and engage. Students were given the choice of two foam blocks of various rectilinear, planar or cubical proportions[1]. Students were not allowed to change the proportions of the foam blocks, and therefore, the basic shapes of the foam blocks were the starting point for exploring action opportunities. The restriction to work with standard blocks was a measure to keep the students focused on the process instead of skipping to a poorly thought-through final outcome with advanced form. Working in the *invite* layer, students explored the potential of the foam block proportions to communicate product category (what is the product?) through identification of the basic product sign [3]. By applying

[1] The foam blocks provided were 10x10x10cm, 5x10x10cm, and 5x5x10cm, respectively.

minimal treatments[2] to the foam blocks, they further explored how the form could express basic characteristics (how is the product?), such as properties of weight, balance, or movement. In the *engage* layer, the product is explored for potential-for-use. The form is further refined to communicate information-for-use (i.e., how it describes its interaction) and to guide the user to engage with the object the way intended by the designer (how do I use the product?), e.g., where to hold or place fingers and apply force and movements such as pushing, pulling, and twisting, to achieve a desired use action.

Step 2. User test 1: Looks-like models and peer feedback

A user test was conducted in order to test their interaction hypotheses for the invite and engage layers. In order to simulate real context, the foam block product concepts were mounted on walls or placed on surfaces to reflect the intended use scenario. Four peers assessed the initial design concept and provided written feedback using a prepared question sheet. Designers observed and video recorded their peers testing their design concept, looking not only for intended actions, but also for serendipitous user actions, which could suggest unconsidered opportunities for intuitive use-actions.

Step 3. Enable and confirm: Behaviour and action-completion

Based on the feedback from user test 1, students identified and addressed design issues before moving on to explore the enable and confirm layers. In the *enable* layer, the product guides the user in moving from understanding potential-for-use towards action-completion. As the enable layer involves physical interaction, it requires the refinement of the models from looks-like, to works-like and feels-like states; movements and feedback need to be represented through mechanical components, to simulate behaviour of the object. In the *confirm* layer, users are provided with information confirming action-completion.

Step 4. User test 2: Works-like and feels-like models, user feedback

This step is conducted by inviting external users, previously unexposed to the product concept, for a user test, involving all action layers. Users were invited to interact with the product, without further instructions than being informed that the product is a dispenser. Users commented on their experience of the interaction on a user response form, which was contrasted with a questionnaire completed by the designers on their own intentions with the different action layers.

Step 5. Design refinement and documentation

The final step involved refining the design based on feedback and observations from user test 2 and reflecting upon how the four action layers are implemented in the use of the product. Students documented the real interaction, as developed with users, in a step-by-step user guide.

2.1 Student design case: straw dispenser

The process and key learning points are illustrated by the work of one of the student design teams.

Step 1. Sketches and models were made of a dispenser concept that dispenses a drinking straw by pushing a button on the front of the dispenser. The intent with this particular concept was to invite the user to interact with the underside of the dispenser, which was suggested by using rounded edges to guide the user how to approach the dispenser. Students answered a concept self-evaluation form focussing on their design intent:

Design intent query	**Design team's response**
How does the product invite to use?	"The user notices a rounded edge at the bottom that invites to touching"
How does the product communicate type of dispensed object?	"The shape of the opening"
What is the first action that is engaged by the user?	"Move the hand underneath the dispenser"
How does the product communicate this action?	"By the shape of the rounded edge at the bottom as well as the placement of the product"

However, the students soon realised that they had gone too far in detailing the concept, rather than focussing on developing the interaction. Realising that they had skipped the first basic steps of the process was perceived as a learning point by the students. As a result, they had to back track their

[2] We gave them the restriction of being allowed to manipulate 10% of the total depth of surfaces and edges of the foam blocks.

design process, test the best suitable proportions, and create two variants using minimal edge treatments; one with a rounded edge, and the other featuring a recess to fit the hand.
Step 2. The design team mounted their two product concepts at the intended height to simulate placement of an actual straw dispenser. The peer user test largely confirmed their design hypothesis, indicating that, as intended, all users put their hand under the dispenser. However, all test subjects tried to push the button-part of the model upwards instead of inwards as intended.

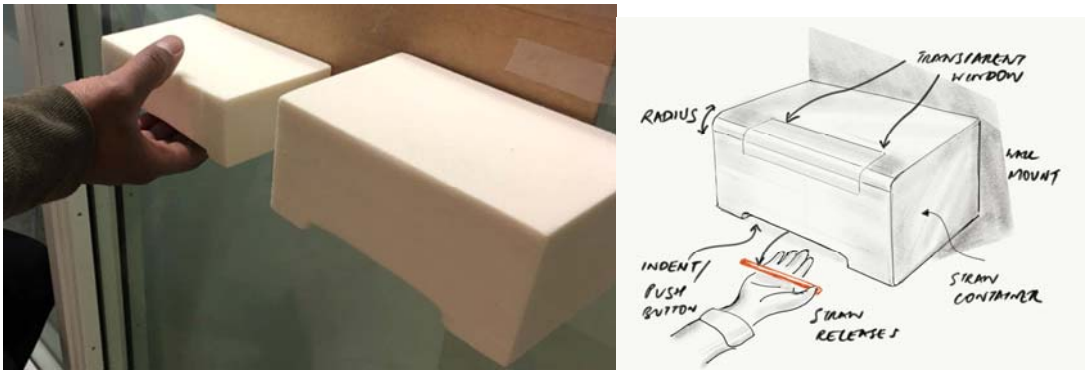

Figure 1. Minimal edge and surface treatment: Based on feedback from user test 1, the students have taken one step back to reconsider how the form invites the user and guides the user in the enable layer to interact as intended with the product

Step 3. Based on the feedback from step 2, a design change was introduced to give the button an upwards motion instead (Figure 2). In order to simulate the dispenser to dispense a straw, student's spring loaded a mock-up of the button, which also provided an audible click to confirm action-completion. This feedback was deemed an especially important to provide information-for-use of the confirm layer, as the mock-up was not fully functioning.

Figure 2. Design of information-for-use on how to engage with the product: a recess under the dispenser leads the fingers and hand towards engaging in an upwards motion

Step 4. In user test 2, other students with no previous knowledge of the product concept provided feedback on the complete mock-up, involving all four action layers. The user test revealed that about half of the users placed the hand underneath the product and performed the intended action, which is indicated by the following feedback:

Response form query	**Test user's response**
How does the user understand what steps or actions that are needed to enable the function of the product?	"By touching the user understands that there is a button to be pressed upwards"
How does the product communicate these actions?	"The product gives direct feedback"
How does the product confirm that the action is correctly executed?	"A straw is dispensed into the palm of the hand"
How does the product communicate that it is back in starting position and ready to be used again?	"The button is returned to its starting position"

However, the other half were observed having difficulties in using the product. For example, users were observed fumbling, not knowing how to approach the dispenser, and pushing the front of the dispenser. Three out of four testers did not seem to entirely understand what actions to perform, or

how to perform them. The user survey revealed that testers believed that parts of the dispenser were to be engaged in a variety of ways, including being pulled; pushed down and lifted upwards; or pushed either inwards or upwards. In this step, the design team realised that the button, while intended to be pressed from underneath, also encouraged users to press it inwards.

Step 5. To provide information-for-use that instructed users to engage the button as intended, grooves were introduced to guide finger placement. With minimal changes from the original foam block concept, the product got a form that described its purpose and interaction style (Figure 3).

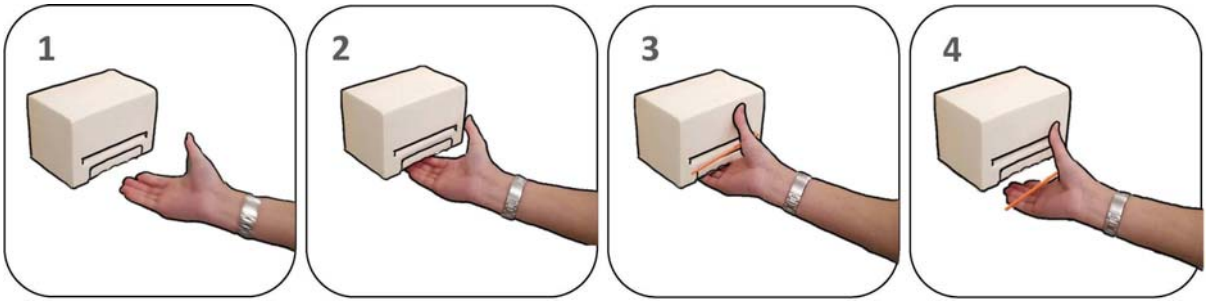

*Figure 3. Action layers of the dispenser concept: 1. Round edge that **invites** the user to approach and touch the bottom surface. 2. Tactile and visible grooves serve as indexes to **engage** in interaction. 3. Indents and grooves guide hand upwards to **enable** interaction, supporting the user towards action completion. 4. Straw is released, falling into the palm of the user and button returns to original position, **confirming** successful interaction*

4 DISCUSSION

In this paper, we propose an experiential learning approach to designing, which supports students to understand, and articulate form, interaction and function concurrently. In doing this, we argue that students avoid the trap of focussing on appearance only, which is a risk if students solely focus on achieving an aesthetically pleasing packaging design. Students are instead supported in recognising and articulating all skills, in an iterative and explorative process of designing for user needs and functionality, as illustrated in Figure 3.

The three-day workshop was evaluated by the students in a course evaluation. In general, the course evaluation suggests that the workshop was appreciated by the students. Evidence of student learning is also present in student reflections in both the individual design workbook that is handed in at the end of the course, and also the group hand-ins that were made during the workshop. One of the students working with the straw dispenser illustrates their learning process in the following quote:

"There were many occasions in the workshop where things didn't go as planned, but afterwards I see that those occasions are also an important part of the process. We test an idea and get results other than we expected, then we need to evaluate what went wrong with that idea, and try in another way. The whole thing is a learning experience, and if everything went right all of the time we would miss out on lots of important insights."

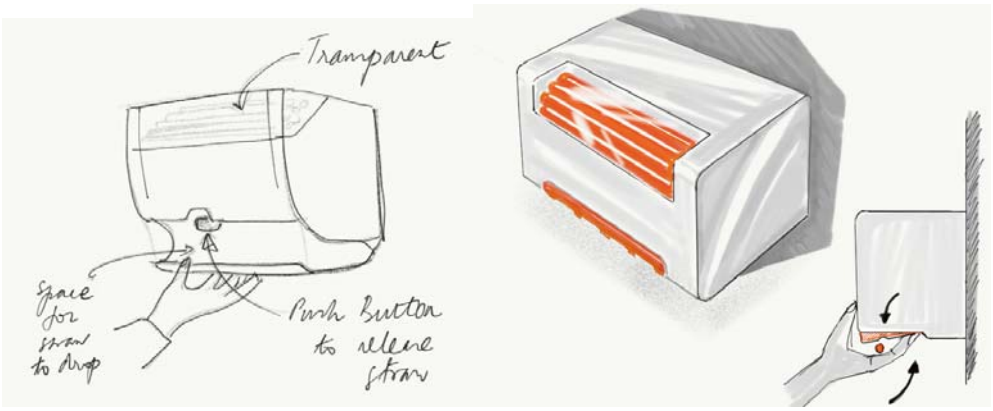

Figure 3. Left: Initial sketch, which illustrates an appearance based approach to the product design concept. Right: Final design, illustrating visual features which guide the user in understanding and interacting with the dispenser

Other student quotes illustrate further learning insights:

"It was fun to try a new way to work – meaning it was interesting to be stopped and forced to go one step back over and over again to tackle new approaches that I had not otherwise seen."

"The workshop made me look at design in a new way. In all future work on product development, I will now think about how the product has to be designed to actually understand it, especially if it is a product that does not resemble any other product."

"I learned how small changes in the shape can make such an unbelievable difference, for example how easily everyone understood that the small recess in the bottom of our first version was for the thumb."

"We realised that even though we were absolutely sure that all users would perform the action the way we intended, they actually did not."

The workshop approach forced the students to stop and reflect upon their design choices and iteratively rework the model if it did not successfully convey the intended message to the user. Another key aspect in the workshop was to test the designs with users to verify how and what the model communicates and how this relates to designers' intention. All in all this led the students to work with providing information-for-use in dialogue with the user, instead of designing features or designs that suit the designers. We believe that the action layers build a foundation for the students on how to think about and design for the different steps that are necessary for user understanding of the product and successful product interaction instead of emphasising aesthetics and appearance.

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